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THE ABANDONMENT OF AGRICULTURAL LAND: A CASE STUDY OF STRELNÍKY, (THE POĽANA BIOSPHERE RESERVE – SLOVAKIA)

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Abstract: The spreading abandonment of agricultural land represents an opposite situation to the increasing intensification of agriculture in many world counties. As a consequence of the changes in traditional ways of land cultivation in Europe, transformation in diversity, ecosystem structure and land degradation occur. Traditional meadows and pastures are receding due the abandonment and secondary succession succeeds. This causes alterations to ecological processes on both the ecosystem and landscape levels. The most frequently stated reason for land abandonment in the post-communist countries of Central and Eastern Europe is the transformation of socialist agriculture to market economy. UNESCO biosphere reserves - such as Poľana - consist of a network of sites that should represent excellent models for landscape management in preserving a range of broad functions and respecting sustainability principles. This research is intentionally focused on this protected area, analysing agricultural land abandonment on the local level in detail. The abandonment of agricultural land in the studied part of the Poľana Biosphere Reserve points out a legitimate worry about the degradation of landscape functions as a result of uncontrolled forest spreading – reforestation.

Keywords: Agricultural abandonment, The Poľana Biosphere Reserve, GIS, change detection, reforestation, UNESCO

1. INTRODUCTION

Agricultural change is a key component in the sphere of land use and land cover change (Tilman et al., 2001; Goldewijk & Ramankutty, 2004; Foley et al., 2005). One of the characteristic features of agriculture from the 1990s is apart from intensification, also the processes of land abandonment typical mainly for marginal areas (MacDonald et al., 2000). As far as abandonment is concerned, crucial are especially mountain areas, because these are the most vulnerable. They create the majority of "less-favoured areas" defined by The European Union (EU) under the terms of Common Agricultural Policy (CAP). About 56 % of all utilized EU agricultural land areas are classified as "less-favourable areas" (Haddaway et al., 2013).

The exact definition of abandonment in agriculture is not easy because abandoned agricultural areas are still in certain transition (Alcantara et al., 2012). According to Keenleyside & Tucker (2010), the abandonment of agricultural land represents a complex and gradual process starting with a progressive marginalization (withdrawal of management) that leads to a reduction in farming intensity (infrequent cultivation, decrease of cultivated areas etc.). The abandonment of agricultural land does not represent a completely new phenomenon. Expansion and subsequent contraction of agricultural land areas have been common since the origins of agriculture (Ramankutty & Foley, 1999; Alcantara et al., 2012; Tullus et al., 2013). However, these days the abandonment of agricultural land is increasing on a global scale (Kauppi et al., 2006; Cramer & Hobbs, 2007; Benjamin et al., 2005).

The causes of abandonment are of ecological as well as of economic character (Cramer, et al., 2008). In the post-communist countries of Central and East Europe the economic reasons dominate.

These are directly related to socio-political changes in these countries. They led to the transition from a socialist agriculture to a market-oriented economy (Peterson & Aunap 1998; Gellrich et al., 2007; Müller et al., 2009; Kuemmerle et al., 2011). After 1989, there was a period known as transitional. The shift in the given regions resulted in a fundamental restructuring of agricultural subjects including the price liberalisation of inputs and outputs (e.g. fertilizers), and to the disappearance of guaranteed markets within the Eastern Bloc. The situation was getting worse due to the increasing foreign competition and land or property privatisation (Kuemmerle et al., 2011). The cultivated area of agricultural land was reduced. The result is, according to Henebry (2009), "the most widespread and abrupt episode of land change in the 20th century". In some territories (e.g. Latvia) the beginning of land abandonment occurs earlier as a result of the very socialisation (collectivisation) in agriculture (Nikodemus et al., 2005). Wu (2013) states that the documentation of historical events, that had an influence on biodiversity and land configuration, was one of the ten key topics in landscape ecology during the last decade.

Several authors have been dealing with the problem of abandoned agricultural land mapping in the post-communist countries of Central and Eastern Europe. Studies have been undertaken in Albania (Müller & Sikor, 2006), Estonia (Peterson & Aunap, 1998), Latvia (Nikodemus et al., 2005), Ukraine (Kuemmerle et al., 2011), Slovakia (Midriak et al., 2011) etc. Data concerning the area of abandoned farmland varied in individual countries. Since 1960s the transformation of European land use (with the exception of the Russian Federation) has been characteristic by an increase in forested areas by 10 %, a decrease in arable land by 11 % and a decrease of permanent pastures by 11 % (Nikodemus et al., 2005). The size of abandoned agricultural land is high in most eastern European countries ranging between 10 % and 50 % (Kull et al., 2004).

With regards to the agricultural land in Slovakia it can be stated that there is an absence of land use to a large extent. It represents about 18.6 % (452 000 ha) of all agricultural land in Slovakia (Midriak et al., 2011). Further decrease in agricultural activities gradually leads to the loss of cultural character of rural land and to the deepening of social, economic and demographic problems in individual regions. The significance of this situation in Slovakia has also been proved by a study carried out in cross-border area of Poland, Slovakia and Ukraine (Kuemmerle et al., 2008). Out of these countries, Slovakia has been marked as the one that was affected by abandonment processes the worst, on the level of 20.7%.

Agricultural land abandonment has several serious impacts. It threatens traditional cultural farmland and it is the main factor of biodiversity decrease (Baur et al., 2006; Elbakidze & Angelstam, 2007; Hietel et al., 2004). According to UNESCO biodiversity issues are key particularly in territories of biosphere reserves, where one of the main tasks is integrating cultural and biological diversity, especially the role of traditional knowledge in ecosystem management.

The aim of this research was to evaluate the degree of agricultural land abandonment in Slovakia in detail, in a less-favoured mountain area during the period of twenty years (1986 - 2006). Another aim was to analyse the occurrence of ingrowths processes in relation to the chosen landscape-ecological characteristics (slope, expositional aspect, altitude) and to evaluate the total reforestation of the model area.

The aim of the presented research analyses was to compare the abandonment level in the period of socialist agriculture and in the period after socio-political changes (transformation period) that ended with the entry of Slovakia to the EU.

2. MATERIAL AND METHODS

2.1. Study area

The model area is partly (53.20%) located in the transition zone of the Biosphere reserve Poľana and it is created by a territory of village Strelníky. The Poľana Biosphere Reserve is located in Central Slovakia (Fig. 1) and forests are predominant there. However, agricultural land is also represented (mainly meadows and pastures – permanent grasslands) especially in the border parts. The network of biosphere reserves, which is coordinated by the Man and the Biosphere (MAB) Programme, tries to achieve harmony between the protection of biological sources and their permanent sustainable use. Biosphere reserves are places, where this intention is verified, illustratively explained and carried out.

The area of village Strelníky (Fig. 2) is for the most part created by agricultural land, which covers 61.93 % of the model area. It represents 1081.79 ha of agricultural land, of which 85.15 % is used as permanent grasslands. The whole area is classified as agriculturally less-favoured mountain area.

Figure 1. Location of the Poľana Biosphere Reserve

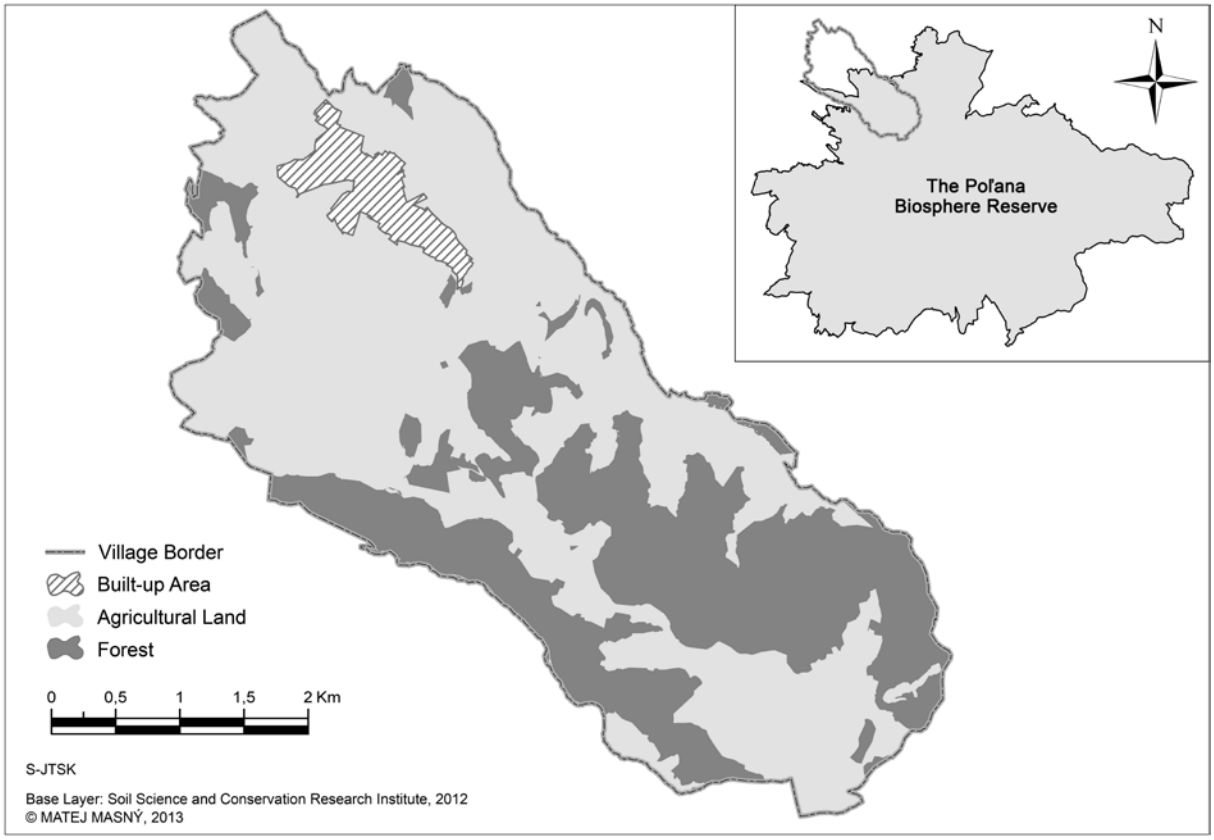

Figure 2. Location and officially registered landscape structure of the model area.

2.2. Evaluation of agricultural land by means of hexagonal net

The main indicator of abandonment by using remote sensing data is the occurrence of woody vegetation in areas formerly used as agricultural land (Alcantara et al., 2012). For the abandonment analysis of the model area we have used high resolution orthophoto images (1500 dpi) taken in 1986 and 2006 and registered in coordinate system S-JTSK (Krovak's projection). Orthophoto images were provided by the Topographic Institute of Slovak Armed Forces. Agricultural land areas were delimited on the basis of official land evidence. This was provided in a form of polygonal shape file by Soil Science and Conservation Research Institute (Slovakia). Abandonment of agricultural land was analysed in ArcGIS 9.3 (ESRI) environment in two phases.

In the first phase, the agricultural land was overlaid by a net of regular hexagons, each of them 2500 m^2 large. In total a net of 4233 hexagons was created. Regular nets application is often used in study of ecosystems and landscape structure (Birch, et al., 2007).

Hexagons represent the best net shape closest to a circle and therefore minimise corner effects

(Tappeiner et al., 2008). Each hexagon was subsequently visually evaluated and included in specified ingrowths class. We used Gallayova's scale (2008) that was applied when evaluating ingrowths processes in other parts of the Biosphere reserve Poľana (Table 1). Data about change in the intensity of ingrowths classes was obtained as difference in the values of individual hexagons between the evaluated periods.

Table 1. Ingrowths classes in the hexagonal net

Proportion of woody vegetation cover in the hexagon (%)	Ingrowths Class
0	1
1 – 10	2
11 – 25	3
26 – 50	4
51 – 75	5
76 – 100	6

The statistical relationship of this change to the chosen terrain qualities (slope – interval 5°, aspect – 8 ways, altitude – interval 100 m) was also evaluated. This was undertaken using the principles of the statistical method known as Pearson's Chi-squared test. The strength of the relationship was calculated employing the *Cramer's V Coefficient*. Its calculation is based on the contingency table (Upton & Cook, 2008). To interpret final index values (effect size) the scale by Cohen (1988) was applied. Values up to 0.1 represent trivial statistical dependence, between 0.1 and 0.3 a small dependence, from 0.3 to 0.5 a medium dependence and values over 0.5 mean a large dependence.

2.3. Analysis of woody vegetation on the agricultural land

In the second phase of the research analysis, the woody vegetation on the registered agricultural land was classified into the following five categories:

1) continual spreading of registered forests
2) ingrowths in road lines
3) ingrowths in watercourse lines
4) strip ingrowths between individual areas of agricultural land (balks)
5) dispersed groups of trees and shrubs

Delimited areas were verified in the field to establish the character of woody structure (shrubs or trees). According to the definitions of forest by the Food and Agriculture Organization (2010) all the delimited polygons were divided into two basic categories. First category was represented by areas defined as a forest; the second category included other woody vegetation (groups of trees and shrubs).

3. RESULTS AND DISCUSSION

3.1. The change and the intensity of ingrowths processes

By using the hexagonal net evaluation in both periods (Fig. 3) it was found, that all individual ingrowths classes achieved an area decrease during the studied period, except the class 6 (ingrowths over 75%). Its proportion has increased by more than 8%. Areas without any ingrowths (class 1) have decreased only by 1 %. This refers to the fact that further succession has occurred on sites where woody vegetation already existed. These results pointed out the fact that the area was in a considerable stadium of ingrowths processes already in 1986. In that stage 25.63% of the evaluated hexagons were already affected by ingrowths by more than 51%.

Data about the ingrowths class intensity (Fig. 4) were categorized into three basic types: (1) without any change of ingrowths class, (2) with an increase of ingrowths class, (3) with a decrease of ingrowths class and their proportion was as follows (1) 65.13%; (2) 27.33%; (3) 7.54%. More compact areas with the increase of ingrowths class were identified especially near the forests, or in the places further away from built-up areas (Fig. 5). Predominant was the increase by 1 degree of ingrowths class (Fig. 4). This points out to a rather slow progress of abandonment.

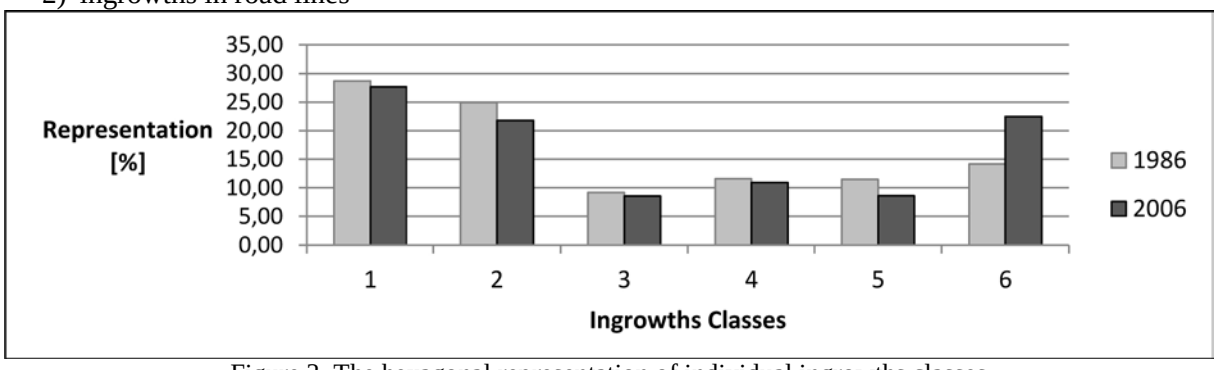

Figure 3. The hexagonal representation of individual ingrowths classes

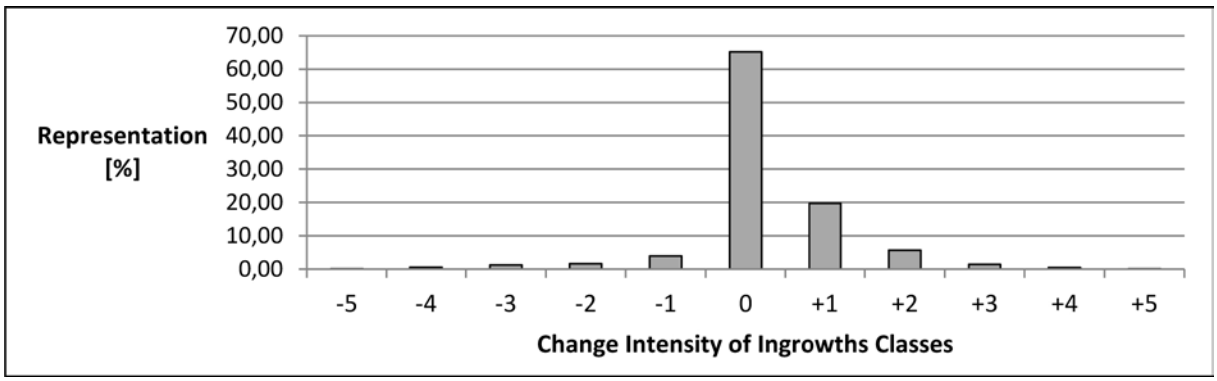

Figure 4. The intensity of change to ingrowths classes in the hexagonal net between 1986 and 2006

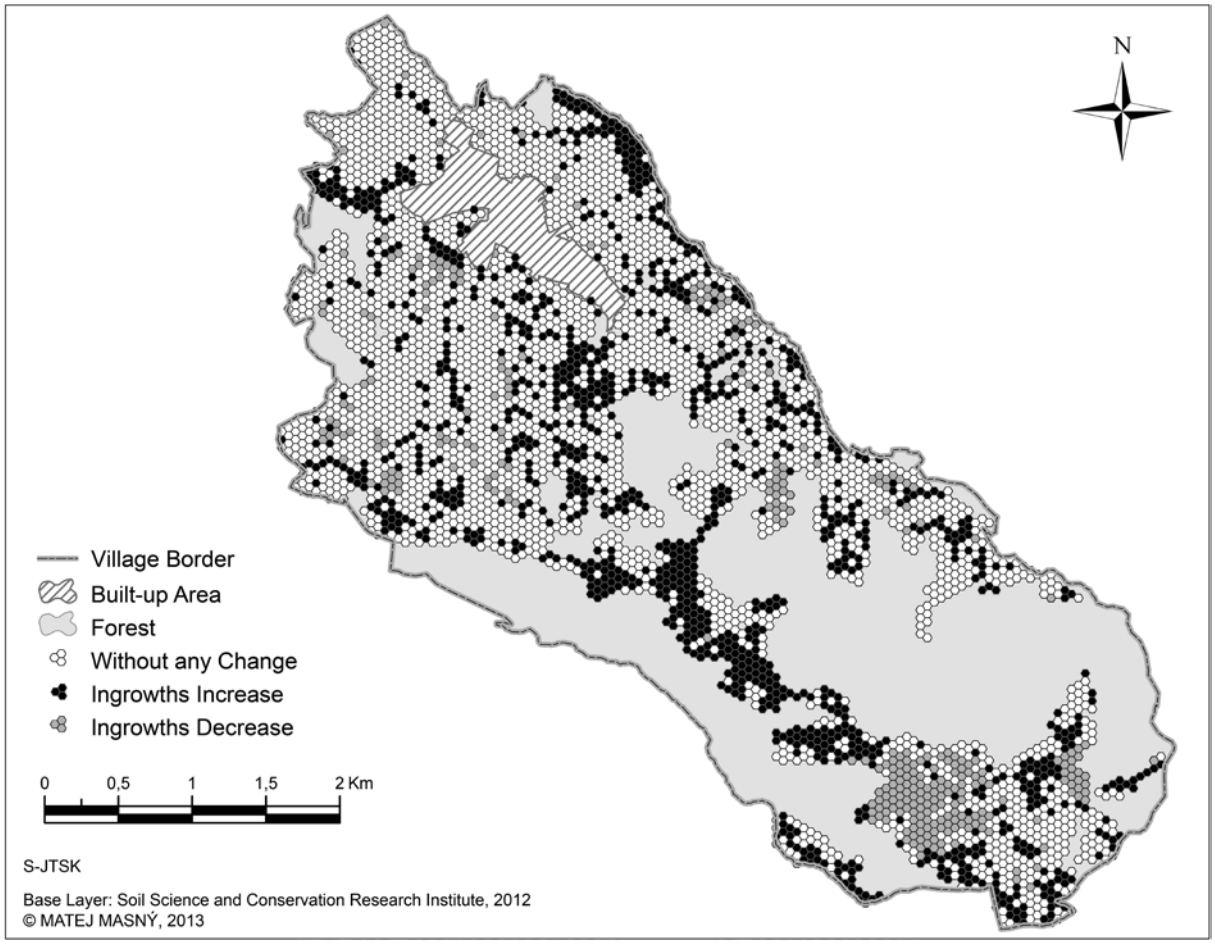

Figure 5. Basic types of ingrowths classes change in the model area

Table 2. The size and proportion of woody vegetation categories on agricultural land

Year	Continual spreading of registered forests		Ingrowths in road lines		Ingrowths in watercourse lines		Strip ingrowths between individual areas of agricultural land (balks)		Dispersed groups of trees and shrubs	
	%	ha	%	ha	%	ha	%	ha	%	ha
1986	302.19	27.93	7.64	0.71	13.74	1.27	3.38	0.31	39.05	3.61
2006	333.94	30.87	10.29	0.95	17.36	1.60	1.52	0.14	37.47	3.46
Difference	31.75	2.93	2.64	0.24	3.61	0.33	-1.87	-0.17	-1.58	-0.15

In the southern half of the studied area more extensive zones with a decrease of ingrowths class were observed (Fig. 5). This was caused by active management procedures such as the permanent

grasslands recultivations. These were carried out in the 1990s. Local implementation of recultivations confirms non-linearity of an abandonment process without fixed patterns (Alcantara et al., 2012). In spite of recultivations carried out, it was possible to observe a general increase in ingrowths on farmland.

3.2. Statistical dependence of ingrowths intensity on the chosen terrain qualities

Statistical evaluation confirmed a relationship between ingrowths intensity and the chosen terrain attributes (based on CHITEST function in MS Excel). However, for slopes and aspects this was on a trivial level of significance (Cramer's V Coefficient 0.09). In relation to altitude, a small level of significance (Cramer's V Coefficient 0.19) was also found. This point out a mild increase of ingrowths intensity in higher, more outlying localities what was also confirmed by Kuemmerle et al. (2008).

3.3. Evaluation of reforestation on agricultural land

The second phase of the agricultural land analysis in the model area shows a detailed representation overview of individual woody vegetation categories on agricultural land (Table 2). A dominant phenomenon observed was a shift in forest borders, which led to their spreading – reforestation (Fig. 6). In the studied period, 2.93 % of agricultural land was affected in this way. Other observed categories changed only slightly. In category "strip ingrowths between individual areas of agricultural land (balks)" and category "dispersed groups of trees and shrubs" a mild decrease in representation was observed. It could have been caused by the recultivations mentioned above, possibly by their integration into the spreading forests.

Acquired data about woody vegetation categories on agricultural land were divided into two main groups (Table 3). The proportion of woody vegetation with a forest character has increased by 3.50 % on an agricultural land in the studied period. On the contrary, other woody vegetation categories decreased moderately. In the whole Slovakia, woody vegetation with a forest character covers 273 000 ha of agricultural land; it increases an area of forest by 5.5% (Zaušková, et al., 2012). In the model area, an increase in the proportion of agricultural land ingrowths was 3.19 %. In comparison to the findings of the study carried out by Kuemmerle et al., (2008) in regions of East Slovakia – (in the period 1986 – 2000 reforestation extent was on the level of 20, 2 %), the established value is rather low. However, the general extend of reforestation has increased by up to 33.69 % (Table 3).

Table 3. The generalised overview of woody vegetation on agricultural land

Year	Woody vegetation with a forest character		Other woody vegetation		Total	
	ha	%	ha	%	ha	%
1986	326.55	30.19	39.46	3.65	366.01	33.83
2006	364.41	33.69	36.15	3.34	400.57	37.03
Difference	37.87	3.50	-3.31	-0.31	34.56	3.19

High reforestation extent in 1986 confirmed primal analysis of a hexagonal net. The results have shown that abandonment processes existed here prior to this, like in Latvia (Nikodemus et al., 2005). Socio-political change after year 1989 is therefore not the primary reason of agricultural land abandonment in this area.

Figure 6. A case of forest border shift (on the left) and the result of reforestation (on the right) in the model area

Agricultural areas with high biodiversity such as extensive grasslands still make up about 30% of Europe's farmland. Although its natural and cultural value is recognized in European environment and agriculture policies, the current measures being taken within the framework of the Common Agricultural Policy are not sufficient to prevent their further decline (European Environment Agency, 2010).

4. CONCLUSIONS

In the model area a considerable extent of agricultural land abandonment has been found. Between 1986 and 2006 agricultural land ingrowths were observed by 3.19% in spite of recultivations. However, overall 33.69% of all the agricultural land was affected by reforestation process in 2006. The proportion of other dispersed woody vegetation moderately decreased during the studied period. Statistically significant influence of terrain attributes (slope, expositional aspect and altitude) on the intensity of ingrowths processes has not been confirmed. The reasons for agricultural land abandonment thus outreach the framework of social-economic reforms in the studied area.

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REFERENCES

Alcantara, C., Kuemmerle, T., Prishchepov, A., V. & Radeloff, V., C., 2012. *Mapping abandoned agriculture with multi-temporal MODIS satellite data*. Remote Sensing of Environment, 124, 334–347.

Baur, B., Cremene, C., Groza, G., Rakosy, L., Schileyko, A., A., Baur, A., Stoll, P. & Erhardt, A., 2006. *Effects of abandonment of subalpine hay meadows on plant and invertebrate diversity in Transylvania Romania*. Biological Conservation, 132, 261–73.

Benjamin, K., Domon, G. & Bouchard, A., 2005. *Vegetation Composition and Succession of Abandoned Farmland: Effects of Ecological, Historical and Spatial Factors*. Landscape Ecology, 20, 627–647.

Birch, C., P., D., Oomb, S., P. & Beechamc, J., A., 2007. *Rectangular and hexagonal grids used for observation, experiment and simulation in ecology*. Ecological modelling, 206, 347–359.

Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciencies*. Routledge, New Jersey, 565.

Cramer, V. A. & Hobbs, R. J. (eds.), 2007. *Old fields: dynamics and restoration of abandoned farmland*. Society for Ecological Restoration International, Island Press, Washington, 325.

Cramer, V., A., Hobbs, R. J. & Standish, R. J., 2008. *What´s new about old fields? Land abandonment and ecosystem assembly*. Trends in ecology & evolution, 23, 104-112.

Elbakidze, M., & Angelstam, P., 2007. *Implementing sustainable forest management in Ukraine's Carpathian mountains: the role of traditional village systems*. Forest Ecology and Management, 249, 28–38.

European Environment Agency, 2010. *The European Environment, State and Outlook 2010*. Land Use, Publications Office of the European Union, Luxembourg, 52.

Food and Agriculture Organization of the United Nations, 2010. *Forest Resources Assessment Programme, Working paper 144/E - Terms and Definitions*. Rome, Forestry Department of FAO, 2010, 27 p.

Foley, J. A., De Fries, R. S., Asner, G. P., Barford, C., Bonan, G., Carpenter, S., R., et al. 2005. *Global consequences of land use*. Science, 309, 570–574.

Gallayová, Z., 2008. *Landscape-ecological analyse and using of permanent grasslands in the CHKO Polana* (Slovak language). Technical University, Zvolen, Slovakia, 103.

Gellrich, M., Baur, P., Koch, B. & Zimmermann, N., E., 2007. *Agricultural land abandonment and natural forest re-growth in the Swiss mountains: A spatially explicit economic analysis*. Agriculture, Ecosystems and Environment, 118, 93–108.

Goldewijk, K., K. & Ramankutty, N., 2004. *Land-cover change over the last three centuries due to human activities: The availability of new global data sets*. GeoJournal, 61, 335–344.

Haddaway, N., R., Styles, D. & Pullin, A., S., 2013. *Environmental impacts of farm land abandonment in high altitude/mountain regions: a systematic map of the evidence*. Environmental Evidence, 2:17.

Henebry G., M., 2009. *Carbon in idle croplands*. Nature, 457, 1089–1090.

Hietel, E., Waldhardt, R. & Otte, A., 2004. *Analysing land-cover changes in relation to environmental variables in Hesse, Germany*. Lanscape Ecology, 19, 474–489.

Kauppi, P., E., Ausubel, J. H., Fang, J., Mather, A. S., Sedjo, R., A., & Waggoner, P., E., 2006. *Returning forests analyzed with the forest identity*. Proceedings of the National Academy of Sciences, 103, 17574–17579.

Keenleyside, C. & Tucker, G., M., 2010. *Farmland Abandonment in the EU: an Assessment of Trends and Prospects. Report prepared for WWF*. Institute for European Environmental Policy, London, 93.

Kuemmerle, T., Hostert, P., Radeloff, V., C., Van der

Linden, S., Perzanowski, K. & Kruhlov, I., 2008. *Cross-border Comparison of Postsocialist Farmland Abandonment in the Carpathians*. Ecosystems, 11, 614-628.

Kuemmerle, T., Oloffson, P., Chaskovskyy, O., Baumann, M., Ostapowicz, K. et al., 2011. *Post-Soviet farmland abandonment, forest recovery, and carbon sequestration in western Ukraine*. Global Change Biology, 17, 1335–1349.

Kull, T., Pencheva, V., Petrovic, F., Elias, P., Henle, K., Balciauskas, L., Kopacz, M., Zajickova, Z. & Stoianovici, V., 2004. *3. Agricultural Landscapes.* In: Young, J., Halada, L., Kull, T., Kuzniar, A., Tartes, U., Uzunov, Y., Watt, A. (Eds.), Conflicts between Human Activities and the Conservation of Biodiversity in Agricultural Landscapes, Grasslands, Forests, Wetlands and Uplands in the Acceding and Candidate Countries (ACC). Centre for Ecology & Hydrology, Banchory, 10–20.

MacDonald, D., Crabtree, J., R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., et al., 2000. *Agricultural abandonment in mountain areas of Europe: Environmental consequences and policy response*. Journal of Environmental Management, 59, 47–69.

Midriak, R., Zaušková, Ľ., Sabo, P., Gallay, I., Gallayová, Z., Lepeška, T., Hladká, D., Lipták, J., Šály, R., Krajčovič, V., Eliáš, P., Šebeň, V., Šmelko, Š., Turisová, I., Uhliarová, E., Švidroň, I. & Cochová, S., 2011. *Waste lands and abandonning agricultural landscape of Slovakia* (Slovak language). Matej Bel University, Banská Bystrica, Slovakia, 401.

Müller, D., Kuemmerle, T., Rusu, M. & Griffiths, P., 2009. *Lost in transition: Determinants of post-socialist cropland abandonment in Romania*. Journal of Land Use Science, 4, 109–129.

Müller, D. & Sikor, T., 2006. *Effects of postsocialist reforms on land cover and land use in South-Eastern Albania*. Applied Geography, 26, 175–191.

Nikodemus, O., Bell, S., Grine, I. & Liepinš, I., 2005. *The impact of economic, social and political factors on the landscape structure of the Vidzeme Uplands in Latvia*. Landscape and Urban Planning, 70, 57–67.

Peterson, U. & Aunap, R., 1998. *Changes in agricultural land use in Estonia in the 1990s detected with multitemporal Landsat MSS imagery*. Landscape and Urban Planning, 41, 193–201.

Ramankutty, N. & Foley, J., A., 1999. *Estimating historical changes in global land cover: Croplands from 1700 to 1992*. Global Biogeochemical Cycles, 13, 997–1027.

Tappeiner, U., Tasser, E., Leitinger, G., Cernusca, A. & Tappeiner, G., 2008. *Effects of Historical and Likely Future Scenarios of Land Use on Above and Belowground Vegetation Carbon Stocks of an Alpine Valley*. Ecosystems, 11, 1383–1400.

Tilman, D., Fargione, J., Wolff, B., D'Antonio, C., Dobson, A., Howarth, R., et al., 2001. *Forecasting agriculturally driven global environmental change*. Science, 292, 281–284.

Tullus, T., Tullus, A., Roosaluste, E., Kaasik, A., Lutter, R. & Tullus, H., 2013. *Understorey vegetation in young naturally regenerated and planted birch (Betula spp.) stands on abandoned agricultural land*. New Forests, 44. 591–611.

Upton, G. & Cook, I., 2008. *A Dictionary of Statistics*. Oxford University Press, New York, 512.

Wu, J., 2013. *Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop*. Landscape Ecology, 28, 1-11.

Zaušková, Ľ., Midriak, R. & Šebeň, V., 2012. *„White areas“ (forest on non-forest land) from the viewpoint of abandoning agricultural landscape* (Slovak language). Forestry Journal, 58, 121-128.

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